6.2 Friction

What happens to the force of sliding friction as you add mass to a sled?

Friction is a resistive force that opposes the motion that produces it. You encounter friction all the time. Without friction, cars wouldn't move, you couldn't write with a pencil, and you would have difficulty walking or staying on a chair. In this investigation you will explore the sliding friction between a sled and the SmartTrack.

In this investigation, you will:

- determine the force of friction present when you launch sleds of different mass on the SmartTrack.
- calculate the coefficient of sliding friction.

Materials List

- SmartTrack
- Energy Car sled
- Steel marbles
- Rubber band
- Track feet (2)
- Bubble level
- Velocity sensor
- DataCollector
- Electronic scale or triple-beam balance

1 Observing and thinking about sliding friction

1. Attach a foot to each end of the SmartTrack so it sits level on the table. Check it with the bubble level and adjust the feet as necessary to make the track level.
2. Fasten a rubber band on the launcher. Attach the launcher to the track facing away from the stop end and where the rubber band is at 70 cm (see picture). Place a sled with no marbles on the track and launch it.

a. What force causes the sled to move? What force opposes the sled's motion?

b. What happens to the sled's velocity as it travels along the track?

c. What would happen to the sled's motion if you added marbles to it? Why?

We want to study the force of friction that acts on the sled. It would be convenient if you could measure the force of sliding friction by dragging the sled along the track with a spring scale, but the friction force is too small to measure this way. Instead, you are going to use the velocity sensor to collect acceleration data for the car's motion, and use Newton's second law to calculate the force of friction.

Think through this scenario: You launch the sled and it moves a certain distance along the track and comes to a stop. The net force that acts on the sled equals the force of friction. This friction force decelerates the sled. According to Newton's second law, the force equals the mass times the acceleration (or deceleration, as in this case). So, if you know the sled's mass and deceleration (from the velocity sensor), you can calculate the force of friction that acts on the sled.

$$f = m \times a$$

force of friction = mass of sled × deceleration

2 Designing an experiment

a. How will adding mass to the sled affect the force of sliding friction? Develop a hypothesis to address this question. Your hypothesis should follow this format: "If the sled's mass affects the force of sliding friction, then _____."

b. *Predict*: When you carry out the experiment and see the velocity vs. time graph for the sled's motion, what will the graph look like?

c. *Predict*: When you carry out the experiment and see the acceleration vs. time graph for the sled's motion, what will the graph look like?

Design an experiment to test your hypothesis (2a). You will use the launcher to get the sled moving. Use the velocity sensor to measure the sled's acceleration, and use an electronic scale or triple-beam balance to find the sled's mass. Vary the number of marbles. Here are some things to consider.

- Choose a launch force that will give a reasonable travel distance with all sled masses, and keep the launch force the same throughout the experiment.
- The sled decelerates, which is negative acceleration.
- Consider whether the force of friction is negative or positive.

d. Write out your experiment's procedure in numbered steps.

3 Analyzing the data

a. Create a data table for all your measurements and calculations. Stay true to the units (kg, m/s^2, N).

b. Be sure to view velocity vs. time and acceleration vs. time graphs for each trial of the experiment. How do they compare to your predictions in 2b and 2c?

c. Was your hypothesis confirmed? Briefly summarize your results in a few sentences. Be sure to refer back to your hypothesis.

d. Use physics to describe why you got the results you did in this experiment.

e. The coefficient of friction (μ) is a ratio of the strength of sliding friction between two surfaces compared to the force holding the surfaces together called the normal force. In the case of the sled on the flat track, the normal force equals the weight of the sled. Write an equation for calculating the coefficient of friction between the sled and track.

f. Calculate the coefficient of sliding friction with all the friction force and weight data you collected. Compile the results in a data table, and find the average coefficient of sliding friction for your plastic-on-wood situation.

g. Study the table of representative coefficients of sliding friction below and describe how your calculated coefficient of sliding friction for plastic-on-wood compares.

Surfaces	μ (sliding)
rubber on concrete	0.65
wood on wood	0.20
ice on ice	0.03
glass on glass	0.40
steel on steel	0.57